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Review Paper on Target Detection Using Ordered Statistical Method

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Abstract - *The main aim of constant false alarm rate(CFAR) in radar to detect the target in an unknown , time varying clutter and noise environment while maintain the constant value of false target detection. Conventional filter fail to set the threshold value to detect the target due to the time-varying nature of noise/clutter power. CFAR is a adaptive algorithm that not only detect the radar target but also maintain the increasing false target detection. Existing CFAR algorithms are effective during certain environment only. So new adaptive threshold technique is used to detect the target called variability index constant false alarm rate(VI-CFAR) which is combination of CA-CFAR, GO-CFAR and SO-CFAR. VI-CFAR adapt itself to different algorithm depending upon wether the environment is homogeneous, Non-homogeneous and multiple target. Performance of VI-CFAR is better than CA-CFAR, GO-CFAR and SO-CFAR. VI-CFAR give low loss performance for homogeneous environment and robust performance for non-homogeneous and multiple target environment.*

***Key Words*: Noise background environment, Constant false alarm rate (CFAR), Variability index and mean ratio.**

1. INTRODUCTION

A stream of radar pulses is given to the duplexer . Duplexer will on the transmitting antenna and pulse is transmitted toward target .At that time Duplexer will off the transmitting antenna and on the receiving antenna . The return signal is allowed to display. This received signal not only consist of noise but also clutter. Clutter is unwanted noise signal which is not of radar use . The example of clutter is the signal return from mountain ,rain drop etc. Most of the technique uses matched filter to fix the threshold but it fail due to the presence of noise and clutter in received signal. In radar target detection the probability of false alarm rate is directly proportional to the amount of noise present in received signal .So the small increasing in total noise power will increase the probability of false alarm to larger factor .

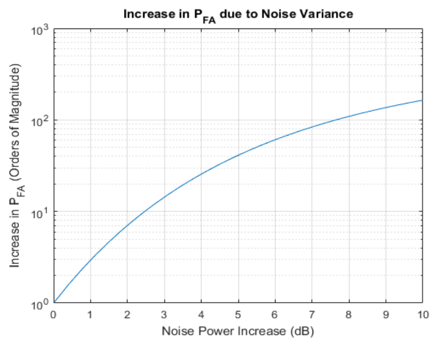

Fig -1: effect of noise power on P_{FA}

Here it is seen from the graph that the desired probability of false alarm is 10^0 but due to 8 dB increase in noise power, probability of false alarm is increased by a factor of 10^2 .Some time smaller target produce signal which is weak in nature so may lost completely in noise and clutter or in some cases the amplitude of return echo signal is more than set threshold value such that it is considered as a target. Such cases is called as false target detection. So the threshold must be stronger enough to detect the target in presence of clutter and noise environment. This increasing probability of false alarm will make data processing equipment to saturate. So to maintain this undesirable increasing in PFA ,and to maintain the threshold as per input environment, an adaptive threshold technique is needed. There are different technique that not only maintain false target detection but also reduces the effect of clutter and noise ,one of them is Constant false alarm rate. The basic structure of CFAR is shown in figure 2.

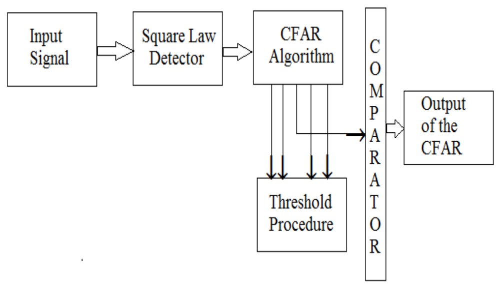

Fig -2: Method to detect target using CFAR algorithm

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Here the input signal is any radar signal which may be homogeneous, non-homogeneous and multiple target which is given to square law detector. Which is then given to shift register where the cell under test value is surrounded by guided cell and reference cell which is given to CFAR algorithm . CFAR processor calculate average value depending upon whether the environment is homogeneous , non-homogeneous and multiple target, which is multiplied with scaling factor to generate threshold value . This generated threshold value is compared with cell under test (CUT) value is use to decide whether the target is present or not. There are various method to detect the target which is based on whether the environment is homogeneous , non-homogeneous and multiple target which is explain in next section.

2. METHODS

So to perform target detection variable threshold is need which may adapt as per background. One such a adaptive technique to detect the target is Cell averaging CFAR (CA-CFAR).

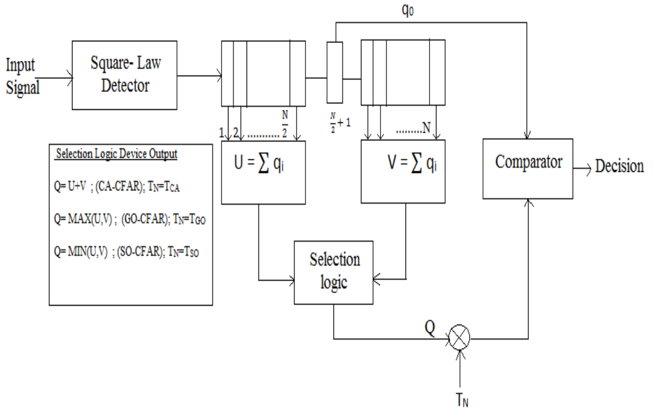

Fig-3: Cell averaging CFAR (CA-CFAR) algorithm

2.1 Cell averaging CFAR (CA-CFAR)

In most of the case, the threshold calculation is based on the amount of noise around cell under test . Target may be present in cell under test or in reference cell. Cell averaging is best to use in homogeneous environment . Homogeneous environment is one which is free from clutter. In this case averaging of cell is used to estimate noise background which is then multiplied with scaling factor is used to give threshold which is compare with cell under test value use to decided whether the target is present in cell under test or not. Adaptive threshold for target cell averaging CFAR is given by

$$Q = U+V$$

Whenever there is a transition from clear to clutter environment is not smooth then performance of Cell averaging CFAR is decreases. This method is not applicable to detect the target when another interfering target is their. To overcome this disadvantage next method is proposed.

2.2 Greatest of CFAR (GO-CFAR)

Whenever there is a transition from clear to clutter is not relatively smooth then two cases arises In first case cell under test is in clear region and number of reference cell in clutter region then adaptive threshold value is increased and probability of false alarm decreases and in second case when cell under test is in clutter region and number of reference cell is in clear environment then adaptive threshold value is decrease and probability of false alarm increases[8]. For such cases CA-CFAR fail to give good performance . To overcome this disadvantage GO-CFAR is proposed . Here the adaptive threshold value is nothing but maximum value between two reference window which is given as

$$Q = Max(U,V)$$

But performance of GO-CFAR decrease in presence of another interfering target in same reference window or its performance decreases in case of Multiple target. To overcome this disadvantage next method is proposed.

2.3 Smallest of CFAR (SO-CFAR)

SO-CFAR uses the same circuit as that of CA-CFAR to detect the target only the difference is instead of average or maximum, SO-CFAR uses smallest value. Instead of choosing the window with higher noise level it chooses the window with lower noise. The adaptive threshold value for SO-CFAR is given as

$$Q = Min (U,V)$$

From above discussed method it is clear that all this method is applicable to particular environment only. As the environment changes performance of different algorithm decreases. So to overcome this disadvantage new algorithm is presented called Variability Index constant false alarm rate (VI-CFAR)

2.4 Variability index constant false alarm rate (VI-CFAR)

Variability index constant false alarm rate (VI-CFAR) is an adaptive algorithm composed of CA-CFAR , GO-CFAR and SO-CFAR. Depending upon whether the environment is homogeneous , non-homogeneous and multiple target , it will adapt itself different algorithm. VI-CFAR select the threshold value based on background estimation algorithm. Background estimation algorithm work based on Variability index (VI) and Mean ratio (MR) values.

[I]. VARIABILITY INDEX STATISTICS

Variability index (VI) is estimation of probability density function (pdf). Pdf of Variability index is independ on noise power in homogeneous environment but affected during interfering target and reverberation within reference window. For each leading and lagging window , VI is calculated and is given by

$$VI= 1+ \frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X})^2 / (\bar{X})^2$$

Which is compare with threshold K_{VI} to decide whether the environment is homogeneous or non-homogeneous.

[II] C. Mean Ratio Statistics

Ratio of mean value of leading reference window A to mean value of lagging reference window B is nothing but Mean Ratio and is given as follow

$$MR = \frac{\bar{X}_A}{\bar{X}_B}$$

Comparison of calculated MR and threshold K_{MR} (1.806) [2] is decided whether the population mean in the leading reference window and lagging reference window are same or different.

[III]. VI-CFAR Threshold Calculation

Adaptive threshold of VI-CFAR is based on the result of the VI hypothesis test and the MR hypothesis test. These result decide which window is used to estimate background power and a constant multiplier which is used to calculate adaptive threshold. The background multiplier C_N and $C_{N/2}$ depend on which reference window is selected to estimate background power. Following table is used to give which method is used to calculate the value of C_N and $C_{N/2}$.

Table-1: DIFFERENT VI-CFAR MODES OF OPERATION [2]

Leading window A variable	Lagging window B variable	Different mean	VI-CFAR Adaptive threshold	CFAR Methods
No	No	No	$C_N . \sum_{AB}$	CA-CFAR
No	No	Yes	$C_{N/2}. \max(\sum_A, \sum_B)$	GO-CFAR
Yes	No	-	$C_{N/2} . \sum_B$	CA-CFAR
No	Yes	-	$C_{N/2} . \sum_A$	CA-CFAR
Yes	Yes	-	$C_{N/2}. \min(\sum_A, \sum_B)$	SO-CFAR

Where $C_N = P_{fa}^{\frac{-1}{N}} - 1$ and $C_{N/2} = P_{fa}^{\frac{-1}{N/2}} - 1$

3. RESULT

While considering homogeneous environment i.e black sample image shown in figure 4 when pass to the algorithm we obtain the probability of false alarm value 0 which is shown in figure 4.

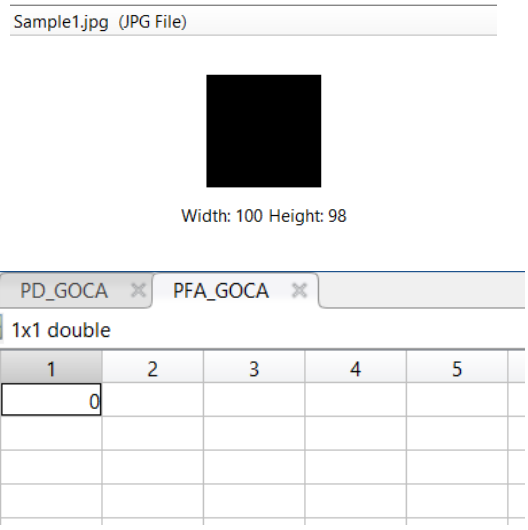

Fig 4-: Black background image 1 sample and obtain PFA value.

Black Background sample image with white target highlighted is shown in figure 5 when pass through algorithm we obtain probability of false alarm value 12. This means the algorithm is able to detect the presence of Target.

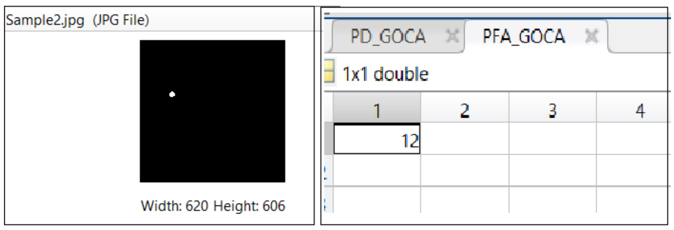

Fig-5: Black background image2 sample with white target highlighted and obtain PFA value.

Figure 6 shows result of CA-CFAR, OS-CFAR, GO-CFAR, SO-CFAR when Black Background sample image with white target highlighted is pass through algorithm.

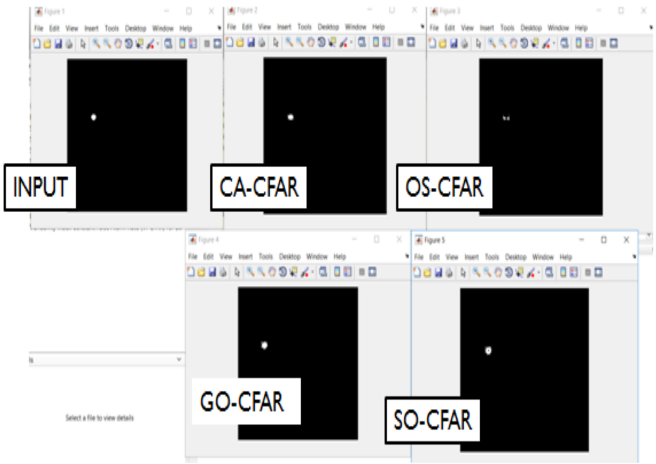

Fig-6: Black background image 2 sample and Result of Cell average-CFAR, Ordered statistic-CFAR , Greatest of-CFAR, Smallest of-CFAR .

3. CONCLUSIONS

Every method is limited to particular environment only such as CA-CFAR performance is good for homogeneous environment Its performance decrease when moving toward clutter environment to overcome this disadvantage GO-CFAR is presented but it is limited to non-homogeneous environment so S0-CFAR is presented to detect multiple target. But none of method detect target in all environment so VI-CFAR is presented which give good performance in all three environment.

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